

Network Science Institute,
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July 28, 2020.

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Brennan Klein

- research [complex systems](#) || [causal emergence](#) || [free energy principle](#) || [teleology](#) || [networks](#)
- current position PhD Student in *Network Science*, 2015—present, Northeastern University. Boston, Massachusetts.
Advisor: Professor Alessandro Vespignani - Director, Network Science Institute.
Dissertation: *Constructing, comparing, and reconstructing networks*.
Committee: Alessandro Vespignani, Samuel V. Scarpino, Tina Eliassi-Rad, Laurent Hébert-Dufresne.
- education B.A. with a double major in *Cognitive Science* and *Psychology*, 2009—2014, Swarthmore College.
Swarthmore, Pennsylvania.
Advisor: Professor Frank Durgin - Professor of Psychology, Perception and Cognition Laboratory.
Thesis: *Angular expansion and the large-scale horizontal-vertical illusion*.
- grants & fellowships *received*, John Templeton Foundation: *Toward a teleology of complex networks*. **Klein, B.** (Co-I), Vespignani, A. (PI), & Scarpino, S.V. (Co-I); December, 2020 – November, 2023.
current, National Defense Science & Engineering Grant (NDSEG); September, 2017 – June, 2021.
- preprints & publications *Working papers & preprints* (* = corresponding author, ¹ = first author, blue text = hyperlink)
- 2020:**
- Klein, B.**¹, LaRock, T.¹, McCabe, S.¹, Torres, L.¹, Friedland, L., Kos, M., Privitera, F., Lake, B., Kraemer, M.U.G., Brownstein, J.S., Lazer, D., Eliassi-Rad, T., Scarpino, S.V., Vespignani, A., & Chinazzi, M.* (*preprint*). [Reshaping a nation: Mobility, commuting, and contact patterns during the COVID-19 outbreak](#).
Version 1 of report [here](#).
- Klein, B.**¹, Holmér, L., Smith, K.*, Johnson, M., Swain, A., Stolp, L., Teufel, A., & Kleppe, A.* (under review, *PLOS Computational Biology*). Resilience and evolvability of protein-protein interaction networks. bioRxiv: <https://www.biorxiv.org/content/10.1101/2020.07.02.184325v1>.
- Hoel, E.*¹, **Klein, B.**, Swain, A., Griebenow, R., & Levin, M. (under review, *Integrative Biology*). Evolution leads to emergence: An analysis of protein interactomes across the tree of life. bioRxiv: <http://biorxiv.org/content/10.1101/2020.05.03.074419v1>.
- Griebenow, R.¹, **Klein, B.**, & Hoel, E.* (under revision, *Journal of Physics: Complexity*). Finding the right scale of a network: Efficient identification of causal emergence through spectral clustering. arXiv: <http://arxiv.org/abs/1908.07565>.
- Hartle, H.¹, **Klein, B.**¹, McCabe, S., St-Onge, G., Murphy, C., Daniels, A., & Hébert-Dufresne, L. (under revision, *Proceedings of the Royal Society A special issue: A Generation of Network Science*). Network comparison and the within-ensemble graph distance.

*Published works***2020:**

Balietti, S.¹, **Klein, B.**, & Riedl, C.* (in press). Optimal design of experiments to identify latent behavioral types. *Experimental Economics*. <http://arxiv.org/abs/1807.07024>

Byrum, T.¹, Swain, A., **Klein, B.**, & Fagan, W. (2020). einet: Effective Information and Causal Emergence. *R package* version 0.1.0. <https://CRAN.R-project.org/package=einet>.

Klein, B.¹ & Hoel, E.* (2020). The emergence of informative higher scales in complex networks. *Complexity*. 8932526, 12 pages. doi: <https://doi.org/10.1155/2020/8932526>.

Kraemer, M.U.G.*¹, Yang, C-H., Gutierrez, B., Wu, C-H., **Klein, B.**, Pigott, D.M., du Plessis, L., Faria, N.R., Li, R., Hanage, W.P., Brownstein, J.S., Layan, M., Vespignani, A., Tian, H., Dye, C., Pybus, O.G.*, Scarpino, S.V.* (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science*. 368 (6490), 493–497. doi: <https://doi.org/10.1126/science.abb4218>.

2017:

Pilny, A.*¹, Poole, M. S., Reichelmann, A., & **Klein, B.** (2017). A structural group decision-making perspective on the commons dilemma: Results from an online public goods game. *Journal of Applied Communication Research*. 45(4), 413–428. doi: <https://doi.org/10.1080/00909882.2017.1355559>.

2016:

Klein, B.¹, Li, Z. & Durgin, F.H.* (2016). Large perceptual distortions of locomotor action space occur in ground-based coordinates: Angular expansion and the large-scale horizontal-vertical illusion. *Journal of Experimental Psychology: Human Perception and Performance*, 42(4), 581. doi: <https://doi.org/10.1037/xhp0000173>.

2013:

Li, Z.¹, Sun, E., Strawser, C. J., Spiegel, A., **Klein, B.**, & Durgin, F. H.* (2013). On the anisotropy of perceived ground extents and the interpretation of walked distance as a measure of perception. *Journal of Experimental Psychology: Human Perception and Performance*, 38(6), 1582. doi: <https://doi.org/10.1037/a0029405>.

2012:

Durgin, F. H.*¹, **Klein, B.**, Spiegel, A., Strawser, C. J., & Williams, M. (2012). The social psychology of perception experiments: Hills, backpacks, glucose and the problem of generalizability. *Journal of Experimental Psychology: Human Perception and Performance*, 39(2), 477. doi: <https://doi.org/10.1037/a0027805>.

awards & honors

recipient, Student Travel Award, Conference on Complex Systems; 2019.

recipient, PhD Network Travel Award, Northeastern University; 2019.

recipient, [Huntington 100](#) Award, Northeastern University; 2019.

recipient, Best Talk Pitch 1st Prize (\$500 for [netrd](#)), NetSci Society Young Initiatives; 2019.

member, Monash University [Networks of Excellence](#); 2018—.

recipient, Best Student Paper Award, Northeast Regional Conference on Complex Systems; 2018.
recipient, National Defense Science & Engineering Grant (NDSEG); 2017.
honorable mention, NSF Graduate Research Fellowship Program (GRFP); 2016.
winner, SwatTank Business Competition (\$3,000 for [Wall.it](#)), Swarthmore College; 2014.
recipient, Community Development Grant (\$10,000 for [SwatDeck](#)), Swarthmore College; 2013.
recipient, Rensselaer Medal, for distinguished students in mathematics and science; 2009.
winner, College Prowler National Admissions Essay Competition; 2009.

selected
invited talks

“[Toward a teleology of complex networks](#)”. *Functional Imaging Laboratory*. Theoretical Neurobiology Meeting of Professor Karl Friston, University College London. London, United Kingdom. (November 14, 2019).

“[The emergence of \(informative\) scaling in random networks](#)”. *Department of Evolutionary and Adaptive Systems*. Artificial Life Reading Group Lecture, University of Sussex. Brighton, United Kingdom. (November 13, 2019).

“[Constructing, reconstructing, and comparing networks](#)”. *Department of Collective Behaviour*. Laboratory of Professor Iain Couzin, University of Konstanz & Max Planck Institute for Animal Behavior. Konstanz, Germany. (October 23, 2019).

“[The structure is the story: How the right representation can bring forth new theories in complex systems](#)”. *Center for Research and Interdisciplinarity (CRI)*. Paris, France. (October 17, 2019).

“[Finding the characteristic scale of causation in biological systems](#)”. *Tufts Center for Regenerative and Developmental Biology*. Laboratory of Professor Michael Levin. Tufts University, Medford, Massachusetts. (December 12, 2018).

“[Does minimizing surprise entail purposefulness? Emergent teleology and parallels to the philosophy of natural selection](#)”. Heins, C. & Klein, B. (joint). *Workshop on Causation & Complexity in the Conscious Brain*. Aegina, Greece. (September 30, 2018).

“[Sufficient causes, necessary effects: Coarse-grained networks are often more informative models of complex systems](#)”. *Complex Systems Lab*. Laboratory of Professor Danielle Bassett, University of Pennsylvania, Philadelphia, Pennsylvania. (August 9, 2018).

“[On getting a PhD in Network Science](#)”. *Network Science Institute*. Northeastern University, Boston, Massachusetts. (July 11, 2018).

“[From network dynamics to algebraic topology in cortical microcircuits](#)”. *Princeton Neuroscience Institute*. Princeton University, Princeton, New Jersey. (March 15, 2018).

selected
conference
presentations

(*Asterisk indicates presenter*)

“[Reshaping a nation: Mobility, commuting, and contact patterns during the COVID-19 outbreak](#)”. **Klein, B.***, LaRock, T., McCabe, S., Torres, L., Friedland, L., Kos, M., Privitera, F., Lake, B., Kraemer, M.U.G., Brownstein, J.S., Lazer, D., Eliassi-Rad, T., Scarpino, S.V., Vespignani, A., & Chinazzi, M. at the COVID-19 Satellite at Sunbelt 2020. (July 20, 2020).

“[Optimizing the design of rugged landscapes to maximally distinguish models of search behavior in humans](#)”. (poster) Fulker, Z.*, **Klein, B.**, & Riedl, C. at the Northeast Regional Conference on Complex Systems (NERCCS). Buffalo, New York. (April 1, 2020).

- “Local edge perturbations as a measure for community persistence in complex networks”. (poster) **Klein, B.*** & McCabe, S. at NetSci. Burlington, Vermont. (May 30, 2019).
- “Comparing methods for reconstructing networks from time series data by comparing methods for measuring network similarity”. **Klein, B.***, Hartle, H., Torres, L., McCabe, S., Yang, C-H., LaRock, T., Shugars, S., Gallagher, R., Sakharov, T., Davis, J., Robertson, R., Mattsson, C., St-Onge, G., Murphy, C., Saffo, D., Mistry, D., Heins, C., Almeida, L., Haque, S., Towlson, E., Zhang, Q., Shrestha, M., Ruf, S., Gates, A., Chinazzi, M., Coronges, K., Riedl, C., Dunne, C., Lippner, G., Eliassi-Rad, T., Vespignani, A., & Scarpino, S.V. at NetSci. Burlington, Vermont. (May 29, 2019).
recipient, 1st Prize: Best Talk Pitch.
- “First Annual Collabathon at the Network Science Institute”. **Klein, B.*** & Coronges, K.* (joint) at the NetSciEd satellite at NetSci. Burlington, Vermont. (May 27, 2019).
- “I would not be surprised...”. **Klein, B.*** & Heins, C.* (joint) at the *Complexity from Cells to Consciousness: Free Energy, Integrated Information, and Epsilon Machines* satellite at the Conference on Complex Systems (CCS). Thessaloniki, Greece. (September 27, 2018).
- “Causal structure as a network: Quantifying certainty in complex systems”. **Klein, B.*** & Hoel, E. at the *Workshop on Causality & Information Flow* at the International Conference on Complex Systems (ICCS). Boston, Massachusetts. (July 26, 2018).
- “Quantifying causal structure and causal emergence in complex networks”. **Klein, B.*** & Hoel, E. at NetSci. Paris, France. (June 15, 2018).
- “Modeling firms responses to information about illicit market activity”. **Klein, B.*** & De Vries, I. at the *NetCrime* satellite at NetSci. Paris, France. (June 12, 2018).
- “Quantifying the causal structure of complex networks”. **Klein, B.*** & Hoel, E. at the Northeast Regional Conference on Complex Systems (NERCCS). Binghamton, New York. (April 13, 2018).
recipient, Best Student Paper Award, sponsored by the journal Complexity.
- “Dynamics of the opioid crisis in the United States”. **Klein, B.***, Strong, K., Salvalaggio, G., Toba, L., & Cavanagh, M. at the Northeast Regional Conference on Complex Systems (NERCCS). Binghamton, New York. (April 13, 2018).
- “Quantifying the causal structure of networks”. (poster & lightning talk) **Klein, B.*** & Hoel, E. at CompleNet. Boston, Massachusetts. (March 7, 2018).
- “Modeling firms responses to information about illicit market activity”. De Vries, I.* & **Klein, B.** at CompleNet. Boston, Massachusetts. (March 6, 2018).
- “Toward the optimal design of social network experiments”. **Klein, B.***, Balietti, S., & Riedl, C. at CompleNet. Boston, Massachusetts. (March 5, 2018).
- “Optimal design for online social experimentation”. Balietti, S.*, **Klein, B.**, & Riedl, C., at Code@MIT. Boston, Massachusetts. (October 27, 2017).
- “Uncertainty, satisficing, & optimal decision-making in complex landscapes”. (poster & lightning talk) **Klein, B.*** & Riedl, C. at Code@MIT. Cambridge, Massachusetts. (October 15, 2016).

workshops & conferences

- Sunbelt 2020 - COVID-19 Satellite, July 20-22, 2020. *virtual.*
- Northeast Regional Conference on Complex Systems 2020, April 1-3. Buffalo, New York.
- Complex Networks Winter Workshop 2019, December 15-21. Québec City, Canada.

Santa Fe Institute Complex Systems Summer School 2019, June 9–July 5. Santa Fe, New Mexico.
 NetSci 2019, May 27–31. Burlington, Vermont.

Co-organizer: Society of Young Network Scientists pre-conference event.

Complex Networks Winter Workshop 2018, December 15–21. Québec City, Canada.

Causality & Complexity in the Conscious Brain 2018, September 29–30. Aegina, Greece.

Conference on Complex Systems 2018, September 23–28. Thessaloniki, Greece.

Satellite co-organizer with Conor Heins: *Complexity from Cells to Consciousness: Free Energy, Integrated Information, and Epsilon Machines*, featuring keynote speakers Professors Karl Friston and Jessica Flack, with invited speakers Professors Martin Biehl, Erik Hoel, William Marshall, Jayne Thompson, Mile Gu, Felix Pollack, Jakob Hohwy, and Rosalyn Moran.

International Conference on Complex Systems 2018, July 22–27. Cambridge, Massachusetts.

Co-organizer: Society of Young Network Scientists pre-conference event.

NetSci 2018, June 11–15. Paris, France.

Co-organizer: Society of Young Network Scientists pre-conference event; Design co-chair.

Northeast Regional Conference on Complex Systems 2018, April 11–13. Binghamton, New York.

Co-organizer: Society of Young Network Scientists pre-conference event.

CompleNet 2018, March 5–8. Boston, Massachusetts.

Co-organizer: Society of Young Network Scientists pre-conference event.

NECSI Winter School on Complex Systems 2018, January 1–12. Cambridge, Massachusetts.

Code@MIT 2017, October 27–28, Cambridge, Massachusetts.

NetSci 2017, June 11–15. Indianapolis, Indiana.

Co-organizer: first Society of Young Network Scientists Symposium.

Code@MIT 2016, October 14–15. Cambridge, Massachusetts.

Vision Science Society Conference 2014, May 16–21. St. Pete Beach, Florida.

Vision Science Society Conference 2013, May 10–15. Naples, Florida.

Vision Science Society Conference 2012, May 11–16. Naples, Florida.

service to the profession *Co-developer, **einet***: an R software package for calculating effective information and causal emergence in networks (<https://cran.r-project.org/package=einet>).

Member, Northeastern University Response Team on COVID-19 (January 2020—present); analyzing data about human mobility in response to the COVID-19 pandemic. Mobility dashboard: <https://covid19.gleamproject.org/mobility>.

Co-author (with Dr. Cynthia Siew, *National University of Singapore*), proposal for the 🌐 (**network**) emoji to be included in Unicode's official list of emojis (under review, *Unicode Foundation*).

Core developer, the **netrd** package in Python: an open-sourced package that includes 20 techniques for reconstructing networks from time series data, 21 graph distance measures, and 7 ways to simulate dynamical processes on networks (<https://github.com/netsiphd/netrd>).

Co-founder, Chair (2017–2019), Outgoing Chair (2019—), Society of Young Network Scientists (SYNS).

Co-organizer: “**I’d like to learn from...**”, a nomination-network themed lecture series featuring presentations from six junior researchers in network science and a **Paper Unwind** with presentations from Professors Austin Benson, Puck Rombach, and Hyejin Youn (*NetSci 2019*).

Co-organizer: **My Favorite Line of Code** featuring presentations from students and Professors Marta Gonzalez, Simon DeDeo, and Esteban Moro (*ICCS 2018*).

Co-organizer: **Publishing in Network Science: Navigating the Maze** featuring a paper writing masterclass by Federico Levi (editor at *Nature Physics*) and a **Paper Unwind** with presentations from Professors Yamir Moreno, Sonia Kéfi, and Stefano Battiston (*NetSci 2018*).

Co-organizer: **Learning, Teaching, and Doing Complex Systems for Young Researchers** featuring tutorials in data science and complex systems from Professors Bruno Gonçalves and Alfredo Morales, as well as panel discussions from Professors Pamela Mischen, Andreas Pape, David Schaffer, Stephen Uzzo, and Hiroki Sayama (*NERCCS 2018*).

Co-organizer: **Paper Unwind** featuring presentations from Professors Tina Eliassi-Rad, Daniel Larremore, and Aaron Clauset (*CompleNet 2018*).

Co-organizer: **SYNS Symposium** featuring presentations from Professors Albert-László Barabási, Brooke Foucault-Welles, Peter Mucha, Kathryn Coronges, Patricia Mabry, Hiroki Sayama, Kevin Chan, Stephen Uzzo, Catherine Cramer, Roberta Sinatra, Alessandro Vespignani, Santo Fortunato, Danielle Bassett, Vittoria Colizza, and *Nature Physics* editor, Federico Levi (*NetSci 2017*).

Reviewer, for the following journals:

PLOS Computational Biology; *Proceedings of the Royal Society: A*; *PLOS One*, *New Journal of Physics*, *Communications Physics*, *Neural Computation*, *Network Neuroscience*, *Proceedings of the National Academy of Sciences*.

teaching & mentorship

Mentor, undergraduate research assistant. August 2019-present.

Chyelle Milgrom, an undergraduate student at the Parsons School of Design, is jointly advised by Professor Jeongki Lim and I on a data science & data art project studying the massive, emergent online experiment that took place on reddit.com in 2017, known as [r/place](#).

Invited lecturer, [Biostatistics](#), Hypothesis testing, test statistics, and introduction to data science. Professor Samuel Scarpino. October 2 & October 4, 2019.

Lecturer, [“Introduction to Complex Systems”](#) at the Network Science Institute Bootcamp for incoming PhD students. September 4-6, 2019.

Lecturer, [“Networks, Network Science, and Python”](#) at the Santa Fe Institute Complex Systems Summer School. June 23, 2018.

Lecturer, [“Introduction to Complex Systems”](#) at the Network Science Institute Bootcamp for incoming PhD students. August 27-31, 2018.

Mentor, Research Science Institute (RSI), June 30-August 4, 2017.

Marissa Sumathipala, a high school student from Ashburn, Virginia, who was awarded by RSI as a top-5 finalist for her work on *Network-based miRNA-disease model for enhancing drug discovery*. I recommended Marissa for the National Center for Women & Information Technology Award for Aspirations in Computing, which she won in February, 2018.

Rucha Joshi, a high school student from Austin, Texas, whose project was called *Evaluating the role of road networks on the onset of conflict in Africa*.

Advisor, undergraduate research assistant. September 2017-September 2018.

Ewen Wang, an undergraduate research student at Northeastern University studying the optimization of experimental design for information gain to the cost of running the experiment.

Lecturer, “Introduction to Complex Systems” at the Network Science Institute Bootcamp for incoming PhD students. August 31, 2017.

Mentor, Research Science Institute (RSI), July 1-August 5, 2016.

Berke Saat, a high school student from Istanbul, Turkey, whose project was called *Applying random walks on probabilistic network topologies*.

selected
popular
writing

[Closing schools will save lives. Keeping them open is a public health hazard.](#) *Arizona Daily Star*. March 15, 2020.

[Swatties, surprise, and a new paradigm of interdisciplinary scientific thought.](#) *Swarthmore College Alumni Magazine*. Spring, 2019.

[SwatDeck, diversity, and the science of networks.](#) *Behavioral Scientist*. 2015.

[When a theory is too good to be true: Fallacies in perception research.](#) *Behavioral Scientist*. 2013.

[The ubiquity of metaphor.](#) *Behavioral Scientist*. 2013.

miscellaneous
& hobbies

Computer: Python/R expertise, MATLAB/Javascript/HTML proficiency.

Language: proficiency in spoken and written Spanish.

High school diploma, *valedictorian*, 2005–2009, Canyon del Oro High School. Tucson, Arizona.

Hobby: I make art under the pseudonym JK Rofling (jkrofling.com).

Exhibitions:

* [Networked](#), a SciArt Initiative exhibition at The Nook Gallery || Los Angeles, California, from July 14th – August 29th, 2019.

* [Only Connections](#), debut show at the Somerville Public Library || Somerville, Massachusetts, from July 2nd – July 30th, 2018.